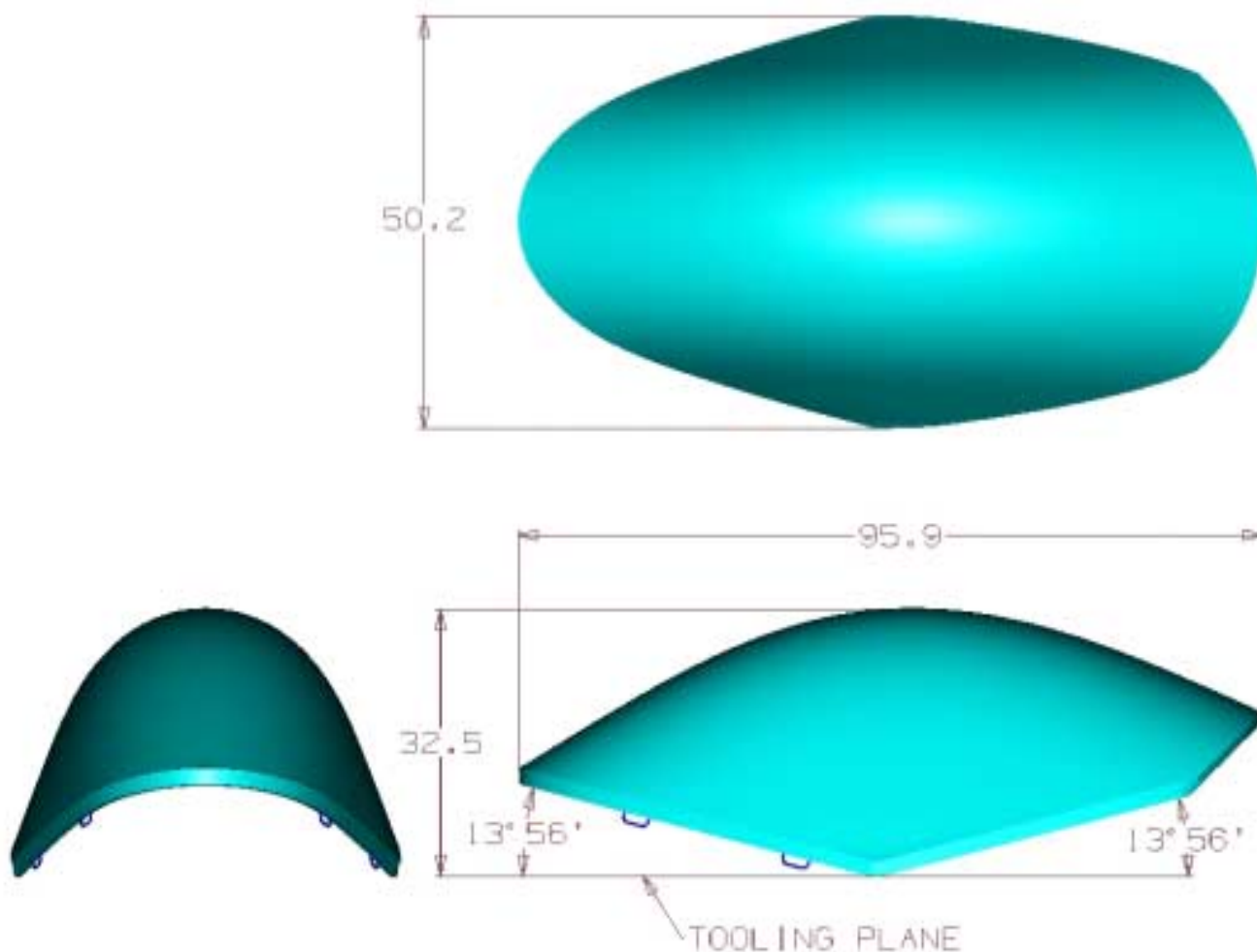




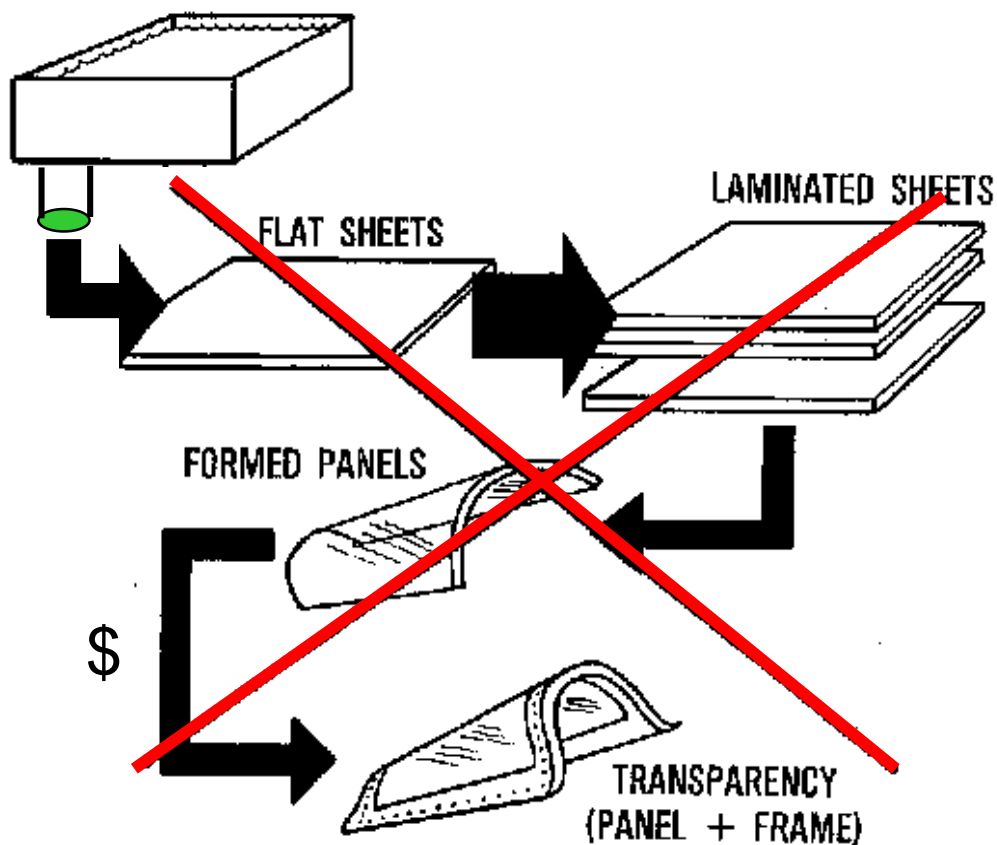
Next Generation Transparency





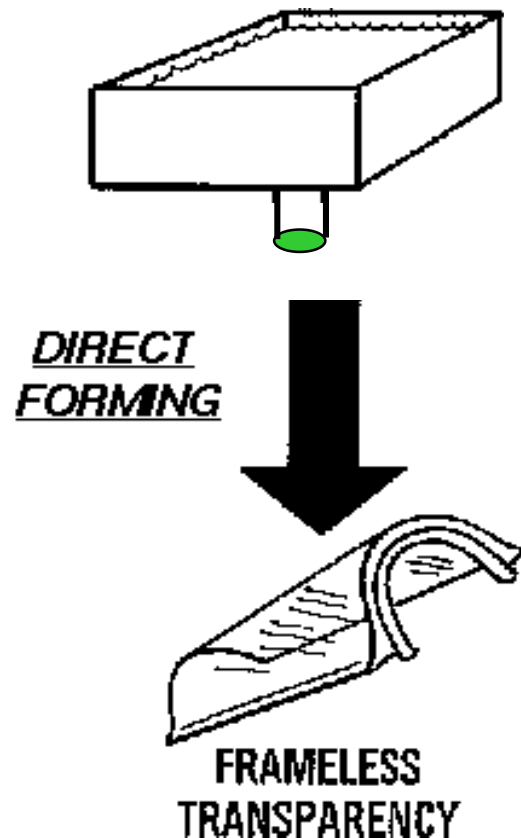
Vision

30 Process Steps For F-16 Canopy



>20% Scrap Rate After Final Optical Tests

9 Steps for Frameless



Ability to Vary Thickness
Saves Weight



Planning / Definition

Goals

- Reduce Production Cost by 80%
- Reduce Weight by 20%
- Reduce Parts Count by 90%
- Reduce Changeout Time by 85%

Payoffs

- Pristine Optics Enable Helmet Mounted Display Integration
- Precisely Repeatable Geometry Enables LO
- Reduces JSF Total Cost of Ownership by \$1.3B

We Can Do It Because

- Two Prior Phases of Work Have Demonstrated
 - Integrated Computer Aided Design Tools
 - Low Pressure Injection Molding Manufacturing Process

Customers : Boeing JSF, F-22, F-15

Needs / Deficiencies : Reduced Support M2, High Reliability LG3, Efficient Turn Times LG6, Extended Preventive Maintenance Intervals LG9, Improved R&M LG7

ATD Ranking : Cat 1



Next Generation Transparency

Objectives

- Demonstrate integration of all technologies required to meet constructed set of next generation transparency system requirements
- Develop initial dual use commercialization plan for autos, commercial aircraft and helicopters

Technical Challenges

- Specification of 'form' for surface of steel injection molding tool required for optical performance
- Development of explosive severance method for emergency crew escape within human acoustic tolerance levels

Approach

- Employ Industry "Best Practices" Tailored for S&T
- Driven by System Customer Technology Assessment
- Align NGT Program Exit Criteria with Customer Entrance Criteria
- Employ Customer Cost Models
- Demonstrate Full Scale Manufacturing Cost to Verify Affordability
- Fabricate Full Scale Articles to Verify Producibility

TASKS/SCHEDULES

TASK	FY98	FY99	FY00	FY01	FY02
Requirements Definition	██████████		██████████		
Element Mold / Test		██████████		██████████	
Final Design			██████████	██████████	
Full Scale Manufacturing				██████████	
Transparency Coating / Test					██████████

Major Milestones

- 1/01 Full Scale System Design
- 3/01 Full Scale Injection Molding Tool
- 1/02 Full Scale Demonstration Articles
- 2/02 Flight Worthiness Qualification

Contribution to Technical Objective(s)

- 550 knot 4 lb Bird Impact Protection
- Metrology accurate to within 10 millionths in. from specified 'form' of the steel tool surface
- Conformal compound curvature lapping tools able to bridge over at least 3 in. on tool surface



NGT Risk Reduction Requirements as Perceived by Boeing JSF Program Office

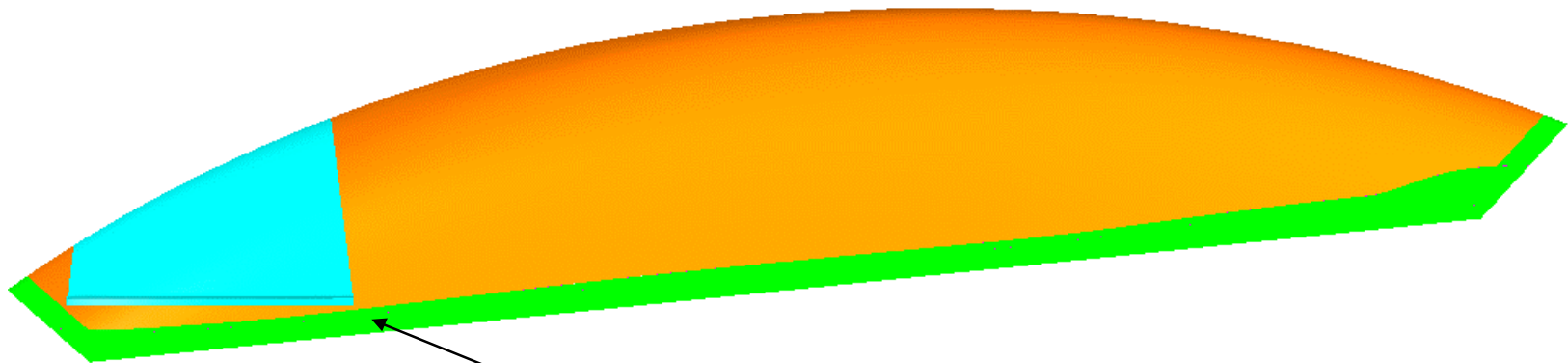
1. **Optics** - Addressing with Deep Optical Element Part
2. **Explosive Severance for Through the Canopy Escape** - Successfully completed three full scale demonstrations with YF-22 canopy articles
3. **Manufacturing Scale Up** - Final design for full scale demo article to be molded next year nearly complete
4. **Structural Integrity** - Sill element articles tested to assess a number of mechanical attachment / seal concepts

- - Progress to date acceptable to Boeing JSF
- - Work in progress to meet JSF optical requirements
- - Principal remaining risk perceived by Boeing JSF



Deep Optical Element Part Definition

- Will Validate Injection Mold Process
- Will Validate New Tool Manufacturing Processes Being Developed
- Will Verify Optic Requirements Can be Achieved and Repeated



Deep Optical
Element Part
(DOEP)



Deep Optical Element Part Injection Molding Trials

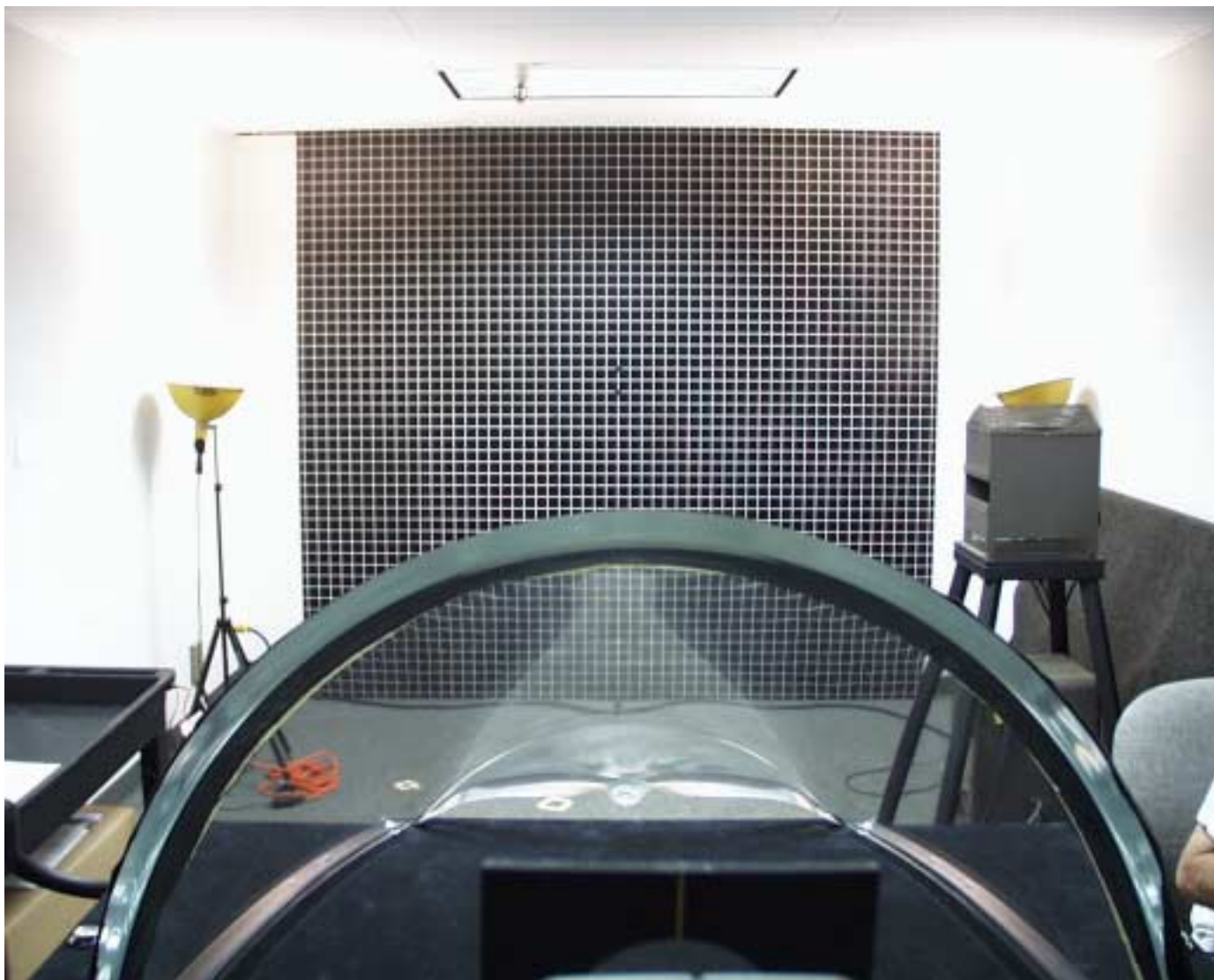


**Injection Molded
Deep Optical Element Part
Articles Exceed F-16 and
F-22 Specifications
for Optical Distortion**

**'Orange Peel' Texture
Must Be Eliminated to
Bring Canopies to Flight Quality**

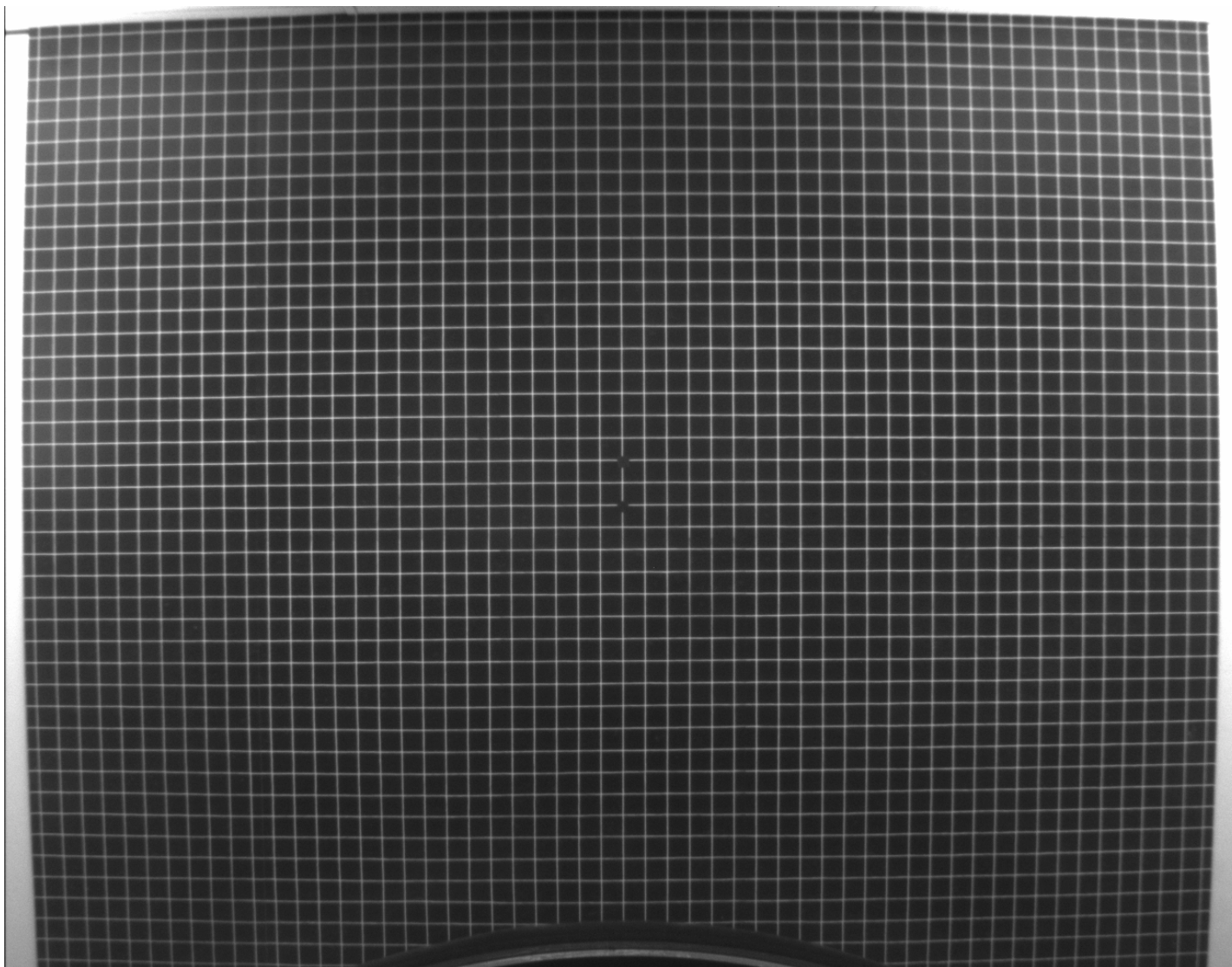


Optical Gridboard Test Setup



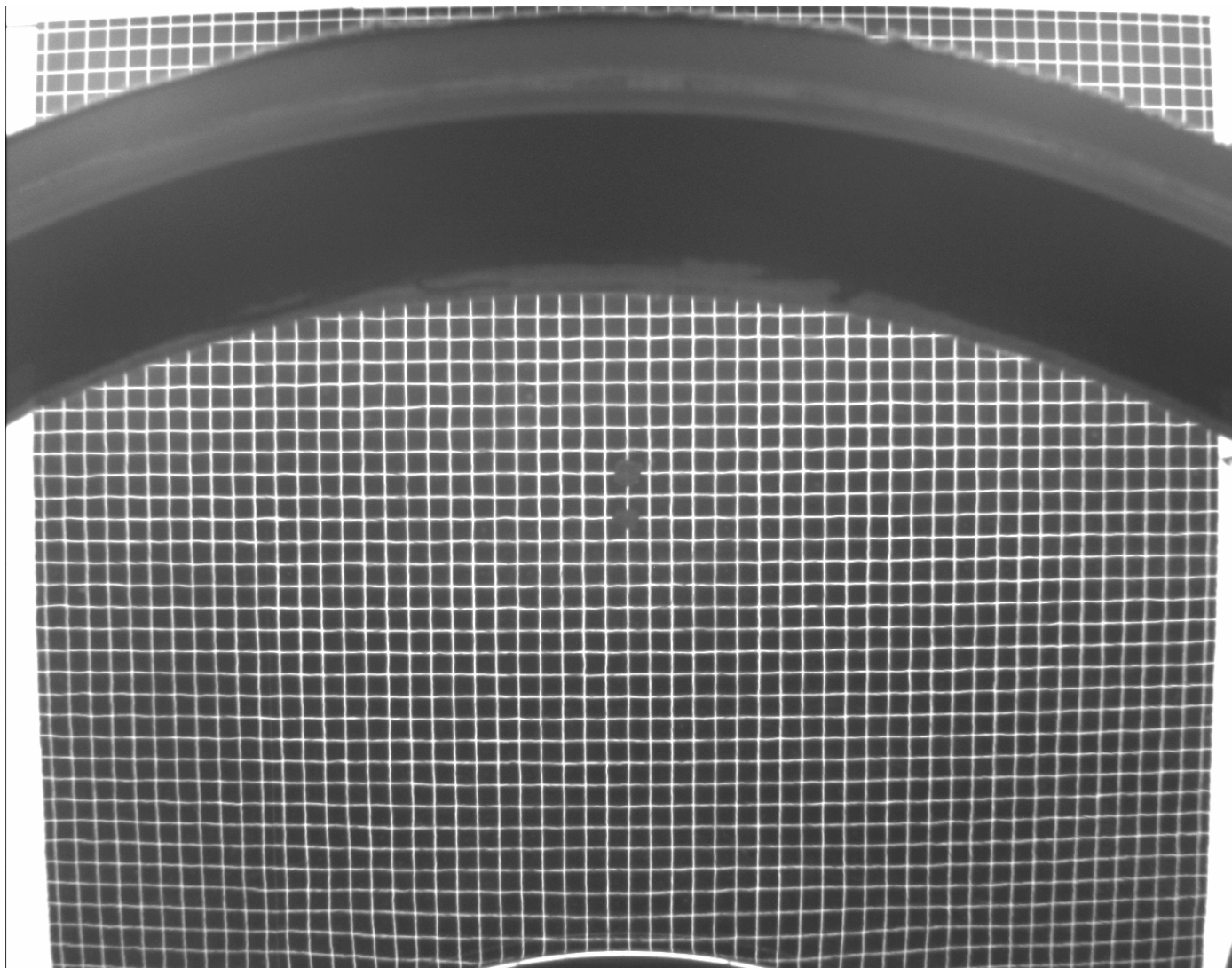


F15E Windshield





Deep Optical Element Part





Optical Shadowgraph Test Setup



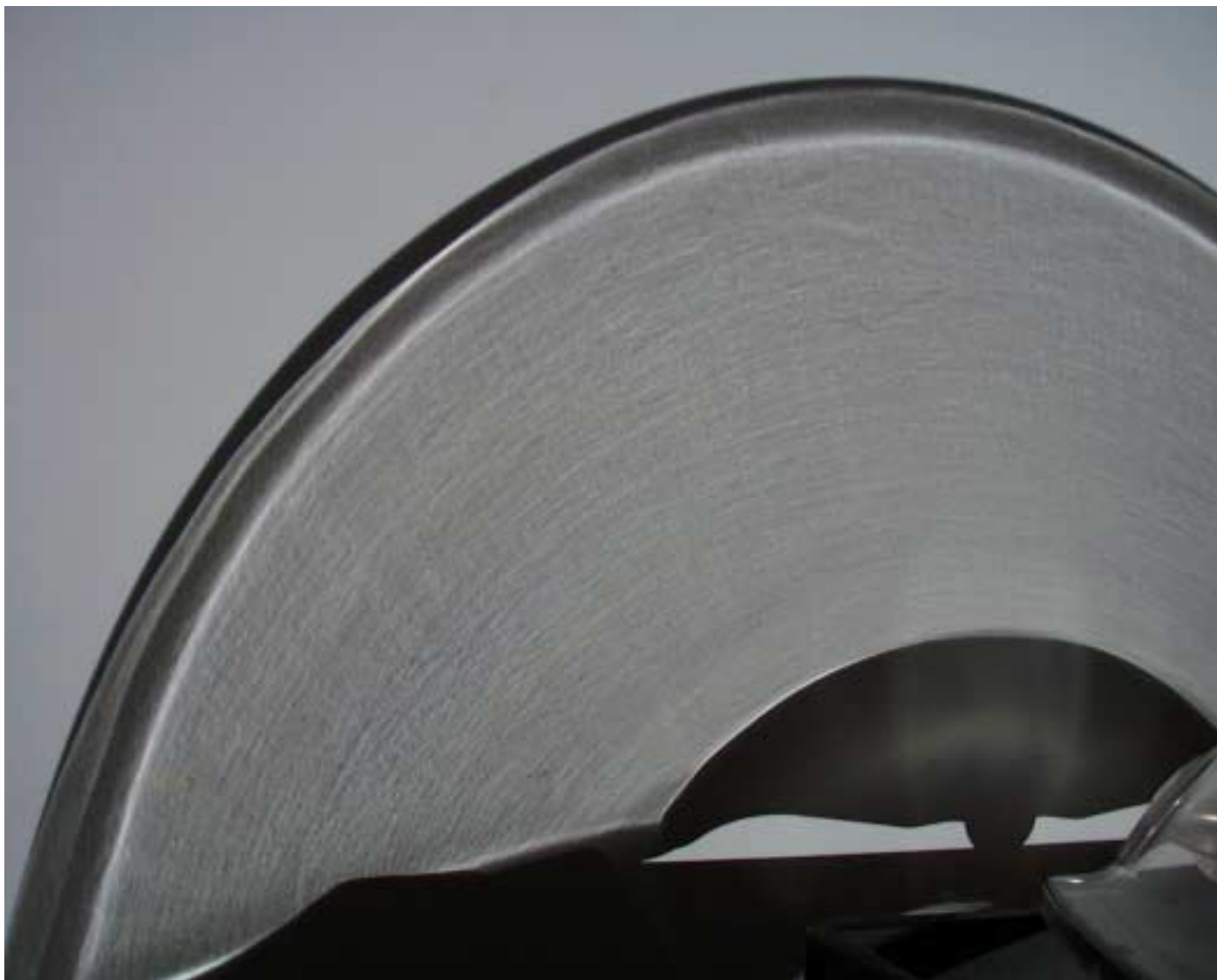


F-15E Windshield





Deep Optical Element Part





NGT Risk Reduction Requirements as Perceived by Boeing JSF Program Office

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Explosive Severance Testing of YF-22 Monolithic Polycarbonate Canopy





NGT Risk Reduction Requirements as Perceived by Boeing JSF Program Office

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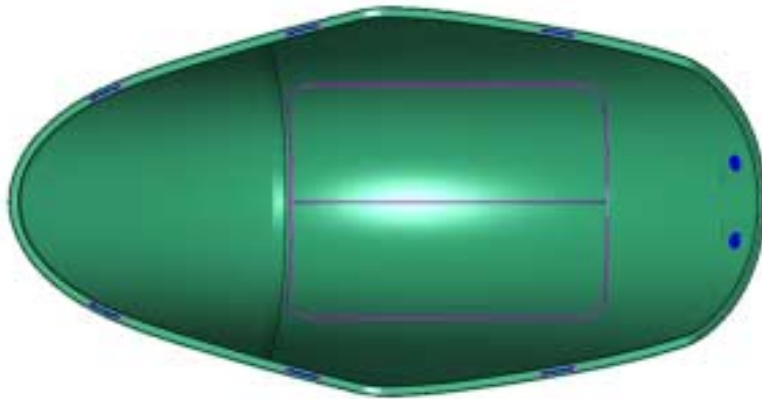
- - Progress to date acceptable to Boeing JSF
- - Work in progress to meet JSF optical requirements
- - Principal remaining risk perceived by Boeing JSF



Full Scale Development Article (FSDA)



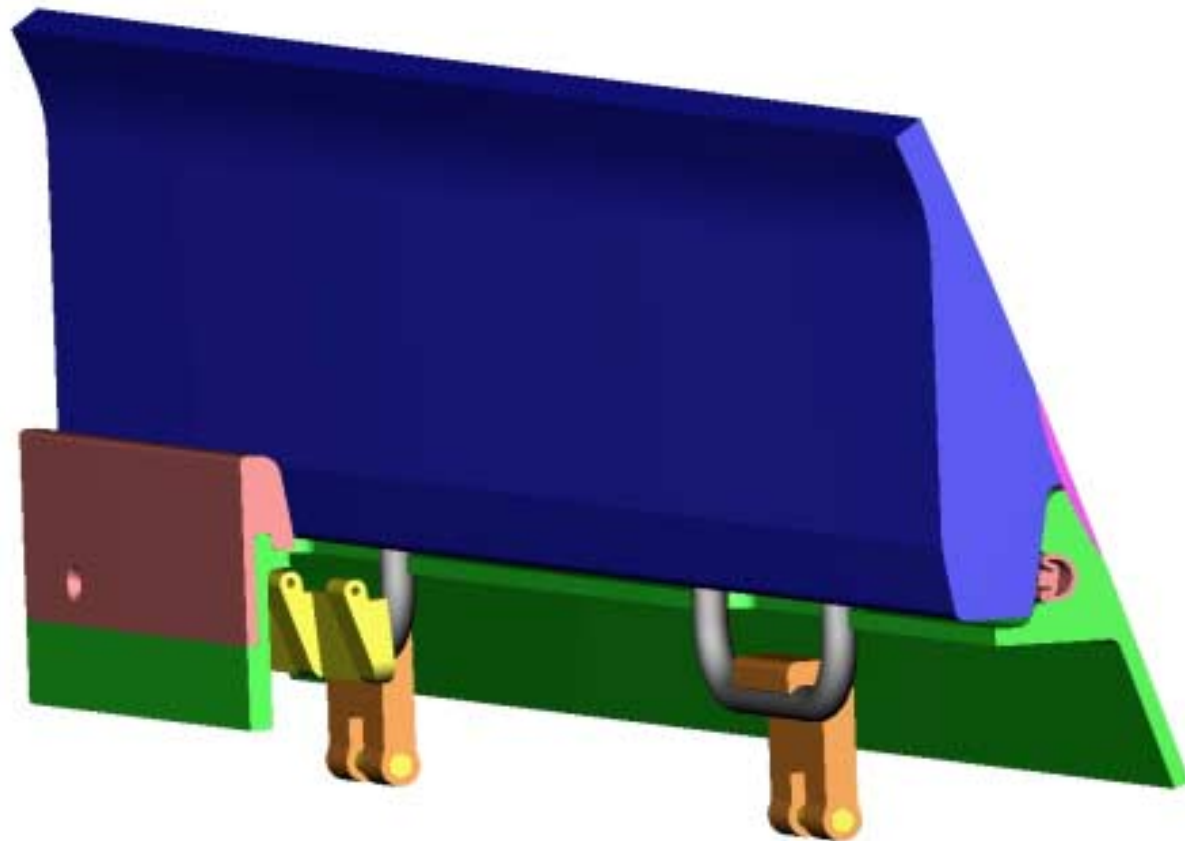
10 Inserts Required:
6 for latching
4 for actuation



Note: Canopy shown in
tool orientation.

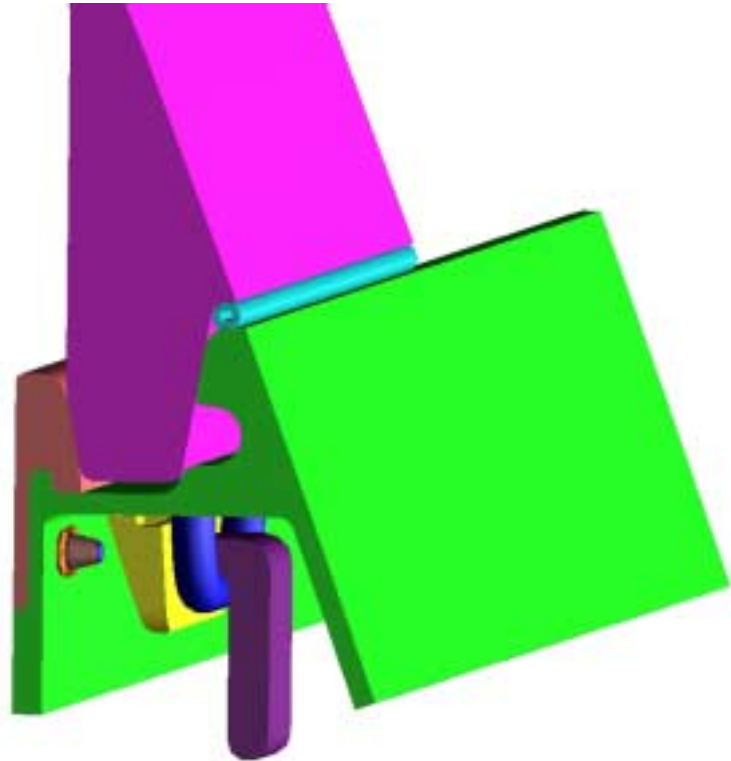
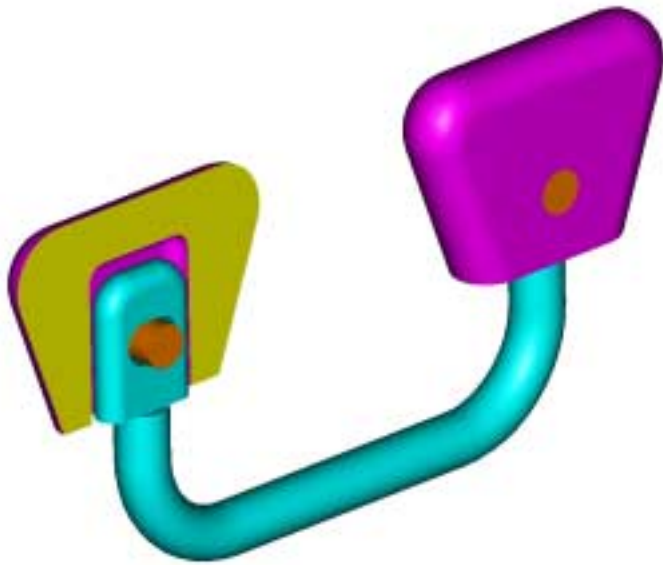


FSDA Latch System





FSDA Latch System Detail





NGT Risk Reduction Requirements as Perceived by Boeing JSF Program Office

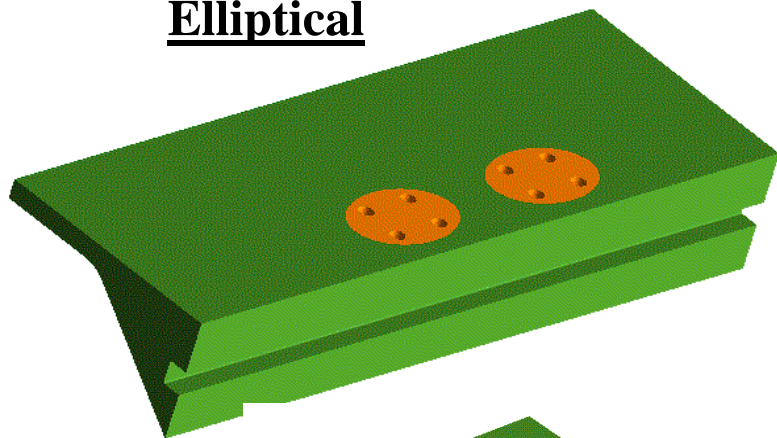
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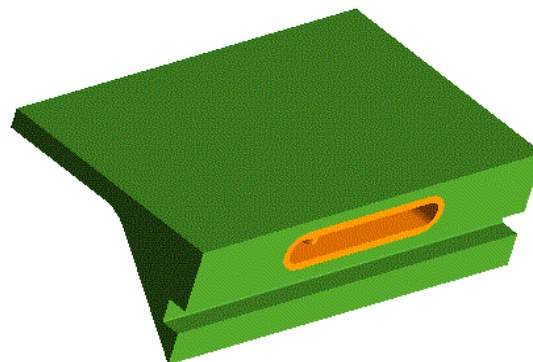


Sill Element Articles

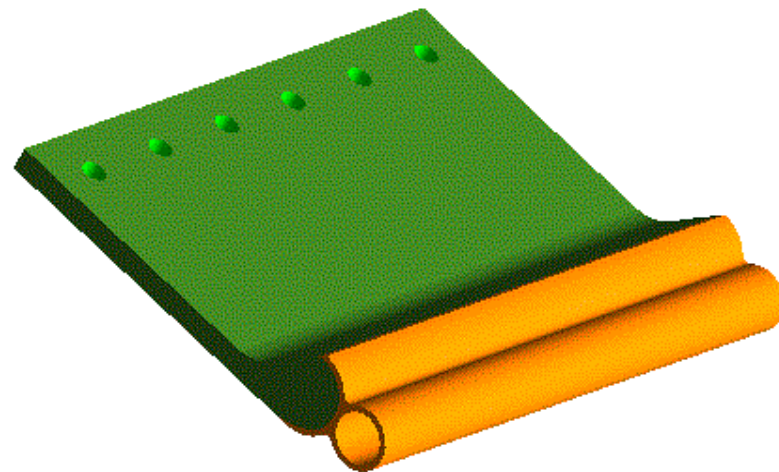
Elliptical



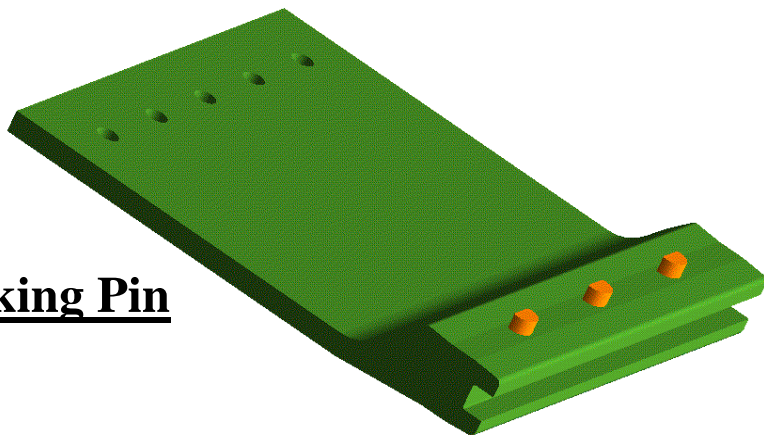
Embedded Pin



Hydraulic Seal



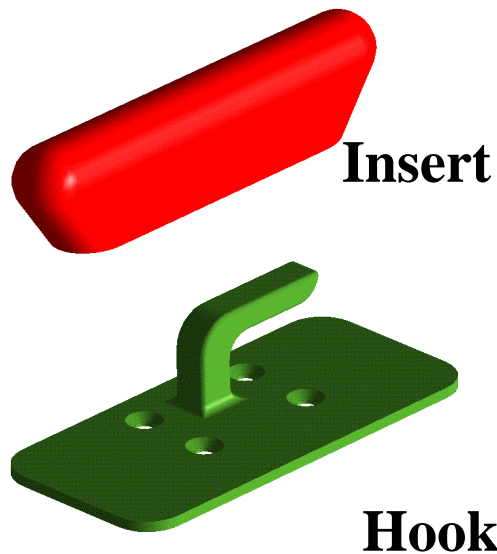
Locking Pin





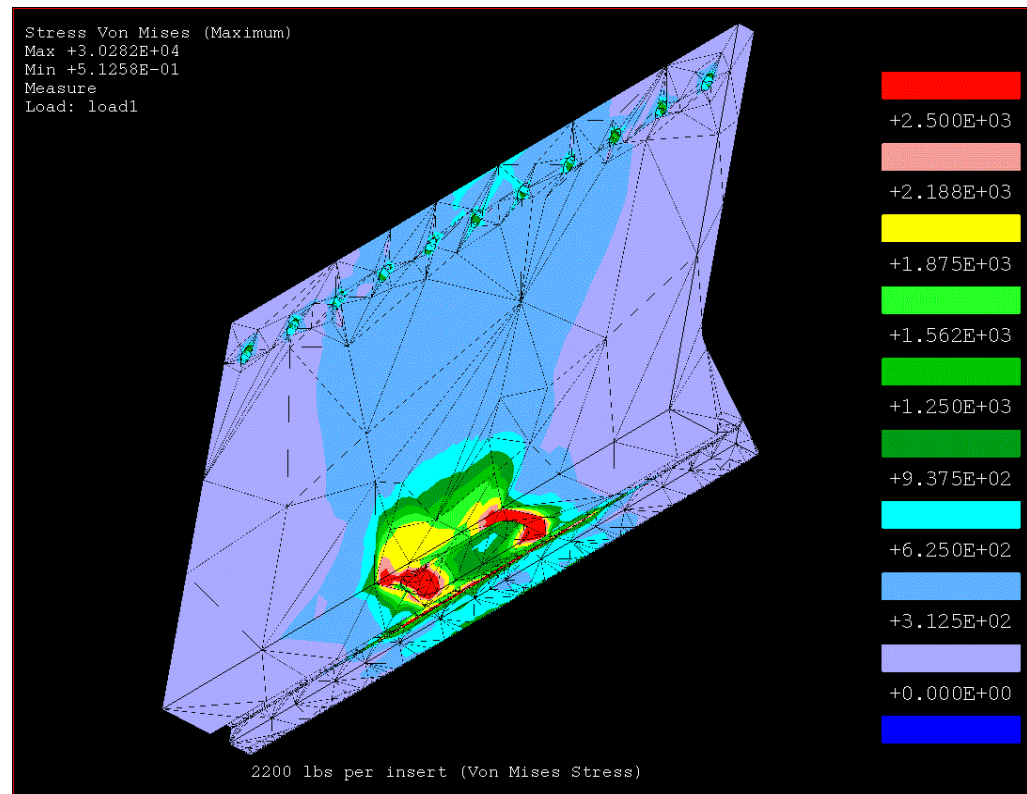
Preliminary Attachment Analysis

- Over 20 Latch and Hinge Concepts Developed
- Selected 5 most promising concepts for further development in task 2



15 Inch Spacing
8.85 psi Pressure
Vertical Load Only

Overmolded Latch Insert - 2,200 Lbs Applied





Correlation of Sill Analysis and Latch Tests

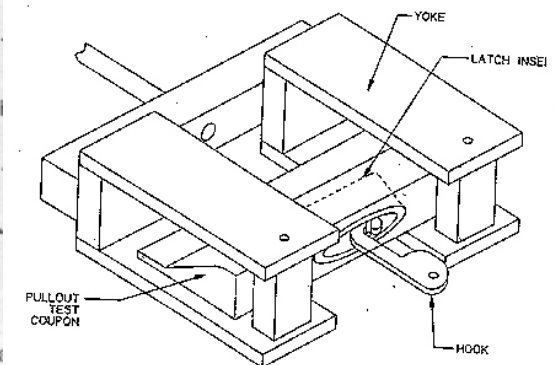
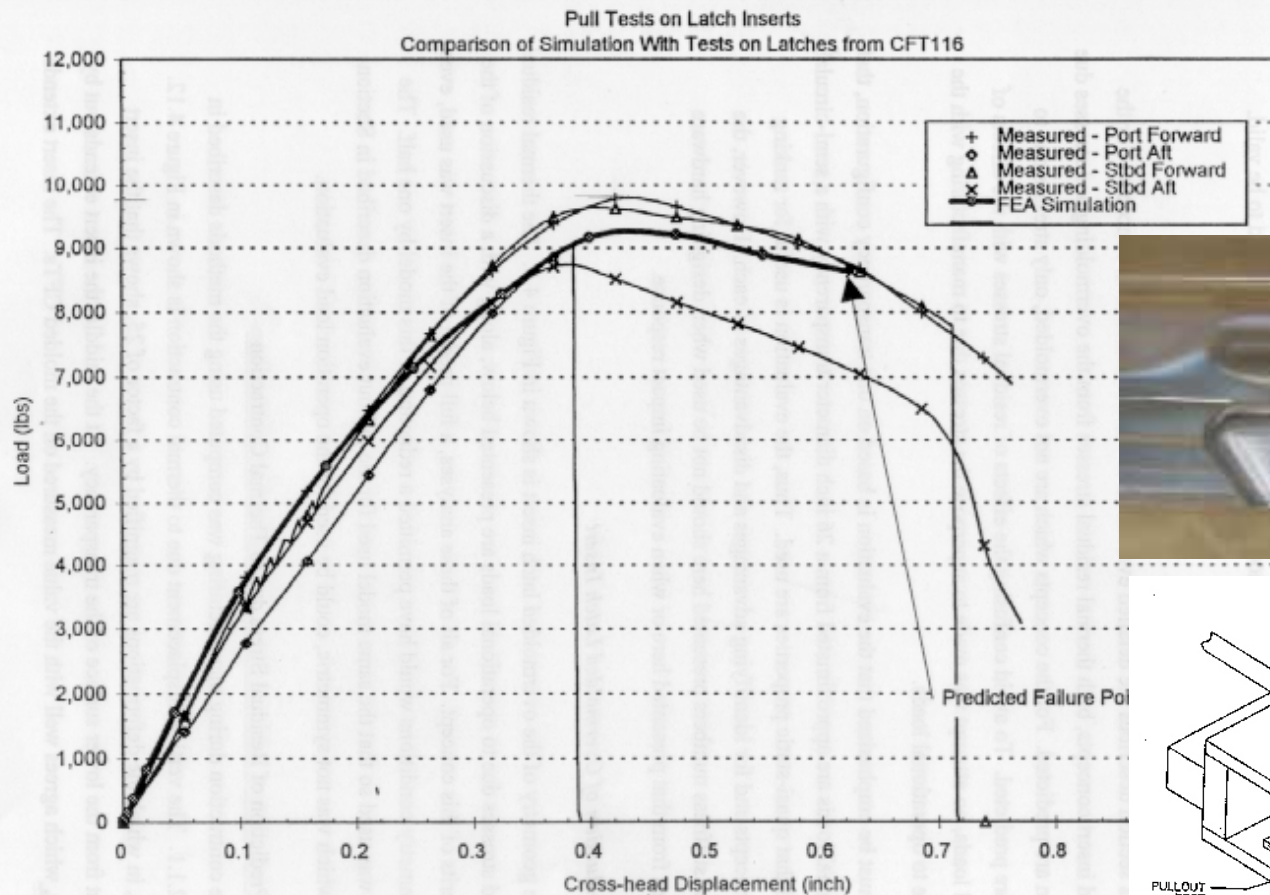


Figure 4.11 Comparison of Simulation and Experimental Data for Pullout Tests of Overmolded Latches

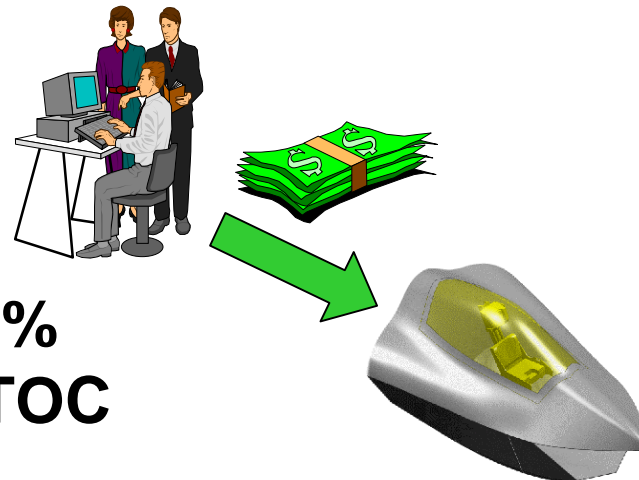
Tests Will Determine the Initial Failure and Pull-Out of the Latches



Transition / Benefits

TTP : HQ AFMC (JSF)
HQ ACC (JSF)
JSF JPO
F-15 SPO
F-15 DSO
F-22 SPO

ROI :



**62%
RTOC**

Affordability :

AFRL Affordability Program

Baselined for:

Boeing JSF

MOU : AFRL/VA & WR-ALC/LF